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Electric mobility breakthrough in FVG

The impact on external costs of the Noemix project

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Introduction

Many, if not most human decisions create external costs. In the case of transport, for instance, using a vehicle causes external costs such as air pollution costs from direct (tank-to-wheel) vehicle emissions, air pollution costs associated with the production of the vehicle and the fuel (well-to-tank), climate change costs, noise costs, congestion costs and other costs.

External costs are borne by an individuals, firms or communities as a result of decisions which they are not directly involved in and are outside their control. At the same time, external costs are not fully perceived or borne by the individual who caused it. Given these characteristics, external costs are not accounted by market prices and are a source of a market failure. The equilibria resulting from individual's decisions lead to suboptimal market equilibria and should be corrected by external costs internalization strategies. A pre-requisite for designing an optimal external costs internalization strategy is their economic evaluation, i.e., estimating the amount of the external costs.

The aim of this report is to estimate the impact on external costs of the Noemix project, that is the impact of substituting 517 conventional cars with 517 electric cars. We consider the following external costs: well-to-tank and tank-to-wheel air pollution costs, climate change costs, and noise costs. We define but do not estimated congestion costs and other costs because they are largely independent from the car's powertrain.

The task is challenging and subject to many uncertainties. It is mainly performed based on the report prepared in January 2019 by Huib van Essen, Lisanne van Wijngaarden, Arno Schroten (CE Delft), Daniel Sutter, Cuno Bieler (INFRAS), Silvia Maffii, Marco Brambilla, Davide Fiorello, Francesca Fermi, Riccardo Parolin (TRT), Kareen El Beyrouty (Ricardo), entitled *Handbook on the external costs of transport, version 2019* (No. 18.4 K83. 131). The report was prepared for the EUROPEAN COMMISSION, Directorate-General for Mobility and Transport, Directorate A — Policy Coordination, and was published in Luxembourg: Publications Office of the European Union. It is quoted as Van Essen et al., (2020).

Since only few external costs were calculated by Van Essen et al. (2020) with specific reference to electric cars, because electric cars were in the initial phase of development, we added some assumptions based on our knowledge of the extant literature.

Definition of the external cost

The definitions provided below are derived from Van Essen et al. (2020).

Air pollution costs

The emission of air pollutants can lead to different types of damages which translate into external costs:

- **Health effects**: the inhalation of air pollutants such as particles (pm10, pm2.5) and nitrogen oxides (nox) leads to a higher risk of respiratory and cardiovascular diseases (e.g. Bronchitis, asthma, lung cancer). These negative health effects lead to medical treatment costs, production loss at work (due to illness) and, in some cases, even to death.
- **Crop losses**: ozone as a secondary air pollutant (mainly caused by the emission of nox and voc) and other acidic air pollutants (e.g. So2, nox) can damage agricultural crops. As a result, an increased concentration of ozone and other substances can lead to lower crop yields (e.g. For wheat).

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- **Material and building damage**: damages can derive from pollution of building surfaces through particles and dust; or via damage of building facades and materials due to corrosion processes, caused by acidic substances (e.g. Nitrogen oxides nox or sulphur oxide so2).
- **Biodiversity loss**: the most important damages are the acidification of soil, precipitation and water (e.g. By nox, so2) and the eutrophication of ecosystems (e.g. By nox, nh3). Damages to ecosystems can lead to a decrease in biodiversity (flora & fauna).

Costs of well-to-tank air pollution emissions

All cost categories discussed above cover direct effects of the transport operation process. However, there is a broad range of other up- and downstream processes directly related to transport that also lead to negative external effects. Taking a life-cycle oriented view on transport, the energy production, the vehicle and infrastructure production, maintenance and disposal all lead to the emission of air pollutants, greenhouse gases, toxic substances and other negative environmental impacts.

The most relevant effects are the emissions due to energy production, often also called well-to-tank emissions. The cost of well-to-tank emissions includes the production of all different type of energy sources which leads to emissions and other externalities. The extraction of energy sources, the processing (e.g. refining or electricity production), the transport and transmission, the building of energy plants and other infrastructures lead to emission of air pollutants, greenhouse gases and other substances. The emissions during the production of energy sources are very relevant in terms of total external costs. The effects of energy production may be very relevant especially for electricity driven transport modes.

Climate change costs

The emission of greenhouse gases into the atmosphere leads to global warming and climate change. Without concrete climate policies, temperatures may be expected to rise significantly by the end of the century. Such radical change will have an important and largely irreversible impact on ecosystems, human health and societies. Climate change costs are defined as the costs associated with all of the effects of global warming, such as sea level rise, biodiversity loss, water management issues, more and more frequent weather extremes and crop failures. Due to the fact that the effects of climate change are global, long-term and have risk patterns that are difficult to anticipate, identifying the costs associated with these effects is extremely complex. For road, the global warming impacts of transport are mainly caused by CO2, N2O and CH4.

Noise costs

Traffic noise is generally experienced as a disutility and is accompanied by significant costs. Noise emissions from traffic pose a growing environmental problem due to the combination of a trend towards greater urbanization and an increase in traffic volumes. The former results in higher noise levels, the latter results in a higher number of people experiencing disutility due to noise. In general, noise can be defined as unwanted sounds of varying duration, intensity or other quality that causes physical or psychological harm to humans. The thresholds above which noise is considered a nuisance are somewhat arbitrary, previous literature has employed thresholds of 50, 55 and 60 dB(A). It is important to note that the choice of a threshold has a substantial impact on marginal noise costs. The exposure to noise results in a number of health endpoints due to prolonged and frequent exposure to transport noise such as ischemic heart disease; stroke; dementia; hypertension; sleep disturbance , annoyance.

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Congestion costs

Congestion is defined as a condition where vehicles are delayed when travelling. In particular, a congestion cost arises when an additional vehicle reduces the speed of the other vehicles of the flow and hence increases their travel time. Since congestion is by and large not related to the type of the car powertrain, it is not considered in this study.

Accident costs

Accidents costs consist of five main components:

- **Human costs**: a proxy for estimating the pain and suffering caused by traffic accidents in monetary value.
- **Medical costs**: the costs of the victim's medical treatment provided by hospitals, rehabilitation centres, general practitioners, nursing homes, etc. As well as the costs of appliances and medicines.
- **Administrative costs**: the costs of covering the expenses of the deployed police force, fire service and other emergency (non-medical) services that assist at the crash location site.
- **Production losses**: due to reduced working time and the human capital replacement costs.
- **Material damages**: monetary value of damages to vehicles, infrastructure, freight and personal property resulting from accidents.
- **Other costs**: such as the costs of congestion resulting from road crashes, vehicle unavailability and funeral costs.

Market prices can be used to calculate material costs, however, no such market prices exist for immaterial costs and they need to be estimated via willingness-to-pay methods. In addition, a part of the total accident costs are already internalized through insurance premiums or accounting for risks that are well anticipated.

Other costs

There are a number of other external costs that could be considered, such as:

- Costs of habitat damage
- Costs of soil and water pollution
- Costs of up- and downstream emissions of vehicles and infrastructure
- External costs in sensitive areas (e.g. Mountainous regions)
- Separation costs in urban areas
- Land use and ecosystem damage for upstream processes
- Cost of nuclear risks

They are not considered in this report since they are highly uncertain, difficult to measure and not always depending on the car powertrain.

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The impact on external costs of the Noemix project

We used a single data source: Van Essen et al. (2020). It is a largely quoted and well-reputed handbook which provides estimates for all transport modes at national level. We refrained from using other literature data in order to assure homogeneity and comparability.

Detailed estimates

The starting point is the current mobility and project data illustrated in Table 1, based on the data concerning the public administration fleet surveyed within the Noemix project (see previous packages).

Table 1 – Current mobility and project data

N° of substituted cars by the Noexmix project	517
% of petrol car substituted	70%
% of diesel car substituted	30%
Average annual km driven	10,500

Table 2 and Table 3 concern the tank-to-wheel and well-to-tank air pollution cost. The unit costs (€-cent/vkm) are based on Van Essen et al. (2020) and our assumptions, as explained below. From Van Essen et al. (2020), we used the estimates concerning Italy, available from the Excel database. The total costs are estimated multiplying the unit costs times the 517 cars, 70% of which petrol- and 30% diesel-fueled, times the average annual driven distance of 10,500 km.

Electric cars cause no tank-to-wheel air pollution costs since they have no tailpipe emissions. On the contrary, they are associated with high well-to-tank air pollution costs associated with energy production. In the case of electric cars, the well-to-tank air pollution costs in Italy are estimated equal to 1.511 €-cent/vkm. Such an estimate is probably based on the 2016 Italian electricity mix. Since an obligation of Noemix project was to produce the electricity consumed by the 517 electric cars using only renewable energy sources (in the specific case of Noemix, a photovoltaic system has been specifically built), we made the assumption that the Noemix electric cars are able to reduce by 90% the well-to-tank air pollution costs, that is they are equal to 0151 €-cent/vkm (maintaining only the air pollution associated with the materials used for the photovoltaic system).

Table 2 – Air pollution cost (tank-to-wheel)

Car type	Unit costs (€-cent/vkm)*	Total cost (€)
Passenger car - petrol (€-cent/vkm)	0.554	21,050
Passenger car - diesel (€-cent/vkm)	1.955	31,840
Electric car	0	-

*Source: Van Essen et al. (2020), data concerning Italy

Table 3 – Air pollution cost (well-to-tank)

Car type	Unit costs (€-cent/vkm)*	Total cost (€)
Passenger car - petrol (€-cent/vkm)	0.650	24,715
Passenger car - diesel (€-cent/vkm)	0.601	9,785
Electric car with the Italian electricity mix (€-cent/vkm)	1.511	82,820
Electric car with the Noemix electricity mix (90% reduction**)	0.151**	8,202

*Source: Van Essen et al. (2020), data concerning Italy; **our assumption

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Table 4 reports the data for climate change. Since no data are provided for electric cars, we made the assumption, in line with several international evidence, that they allow a 50% reduction in climate change costs relative to conventional cars.

Table 4 – Climate change

Car type	Unit costs (€-cent/vkm)*	Total cost (€)
Passenger car - petrol (€-cent/vkm)	1.829	69,493
Passenger car - diesel (€-cent/vkm)	1.769	28,815
Electric car (50% reduction**)	0.90	48,831

*Source: Van Essen et al. (2020), data concerning Italy; **our assumption

Table 5 reports the data for noise costs. Since no data are provided for electric cars, we made the assumption that they allow a 50% reduction relative to conventional cars due the absence of noise from the engine during acceleration and stop-and-go functions.

Table 5 – Noise cost

Car type	Unit costs (€-cent/vkm)*	Total cost (€)
Passenger car - petrol (€-cent/vkm)	1.4	53,978
Passenger car - diesel (€-cent/vkm)	1.5	23,827
Electric car (50% reduction**)	0.72**	39,134

*Source: Van Essen et al. (2020), data concerning Italy; **our assumption

Table 6 reports the data for accident costs. Since the project substitutes old cars with newer electric cars, equipped with the newer safety and accident prevention equipment, we made the assumption that they allow a 30% reduction relative to the old cars.

Table 6 – Accident cost

Car type	Unit costs (€-cent/vkm)*	Total cost (€)
Old passenger car	7.0	377,649
New passenger car (30% reduction**)	4.9*	264,354

*Source: Van Essen et al. (2020), data concerning Italy; **our assumption

Total external cost estimation

In Table 6, we sum up the previous estimates and compare the external costs without Noemix with the external costs with Noemix. The results indicate an annual cost savings equal to €280,631. Over the 5 years of the Noemix project, it implies a total external cost saving of €1,403,155, i.e., €2,714 for each car.

Table 7 – Total external cost savings of Noemix

Cost category	External cost without Noemix	External cost with Noemix	External cost savings/year
Air pollution cost (tank-to-wheel) (€)	52,891	-	52,891
Air pollution cost (well-to-tank) (€)	34,500	8,202	26,297
Climate change (€)	98,308	48,831	49,477
Noise cost (€)	77,805	39,134	38,671

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Accident cost (€)	377,649	264,354	113,295
Sub-Total	641,153	360,521	280,631
Cars' lifetime (years)			5
Total external cost savings of Noemix			1,403,155
Total external cost savings of Noemix per car			2,714

Conclusions and caveats

Our estimate is that the Noemix project generates external cost savings equal to 1,4 million euros (i.e., 2.7 thousand euros per car), over the 5 year time of the project.

Although the data are homogenously derived from the most recent EU Handbook (Van Essen et al., 2020), and were estimated specifically for Italy, our estimates - as all empirical estimates - contain many uncertainties, as explained in detail by Van Essen et al. (2020).

Since, only some external cost estimates were electric-car specific, we added some assumptions based on our knowledge of the extant literature.

List of Tables

Reference

Van Essen, H., Van Wijngaarden, L., Schroten, A., Sutter, D., Bieler, C., Maffii, S., ... & El Beyrouty, K. (2020). *Handbook on the external costs of transport, version 2019* (No. 18.4 K83. 131). Report prepared for the EUROPEAN COMMISSION, Directorate-General for Mobility and Transport, Directorate A — Policy Coordination. Luxembourg: Publications Office of the European Union.